TREATMENT OF NATURAL RUBBER WASTEWATER USING OIL PALM EMPTY FRUIT BUNCH, KAOLIN AND ZEOLITE AS COMPOSITE ADSORBENT

NAZLIZAN BIN NASIR

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Universiti Tun Hussein Onn Malaysia

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DEDICATION

To my beloved mother, Nusibah Mahat
And father Allahyarham Mangsor Bin Mat Aris
For her patient, encouragement and full support
To my beloved siblings,
Nazlina, Nazlita, Nazlisyam, Nazlizul and Ainul Anisah,
For constant support, understanding & love.
To my Lecturers and Friend
For giving me infinite care and blessing.
Thank you for your endless support for me.

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ABSTRACT

The development of composite adsorbents is a new technique applied in wastewater treatment. A combination of few absorbents is proven to be capable of removing pollutants simultaneously compared to a single adsorbent. Thus, the aim of this study is to produce a composite adsorbent from natural zeolite, oil palm empty fruit bunch (EFB) and kaolin bound to chitosan to adsorb colour, chemical oxygen demand (COD) and ammoniacal nitrogen (NH_3-N) from natural rubber wastewater. Batch and fixed-bed adsorption techniques were used in this study. The combination ratio of zeolite, EFB and kaolin as a composite was optimised using D-optimal mixture design (DMD) while the characterization of composite adsorbents was done using Fourier Transform Infrared (FTIR), Field Emission Scanning Electron Microscopy (FESEM), Brunauer-Emmett-Teller (BET) and zeta potential. Batch experiments were carried out to determine the influence of various factors namely adsorbent dosage, pH, shaking speed and contact time of adsorption colour, COD and NH_3-N on the composite adsorbent. Langmuir and Freundlich models were used to investigate isotherm adsorption while pseudo-first order, pseudo-second order, intra-particle diffusion and Elovich were used to examine kinetic behaviour. The fixed-bed adsorption performances were evaluated by varying the influent flow rate (2, 2.5 and 3 mL/min) while the adsorption kinetics was analysed using Thomas, Yoon-Nelson and Adam-Bohart kinetic models. The regeneration of the composite adsorbent for up to five adsorption/desorption cycles was also investigated. According to the results, the composition of 0.4g zeolite, 0.8g EFB and 0.8g kaolin was the best ratio in terms of colour, COD and NH_3-N removal from natural rubber wastewater. FTIR and FESEM analyses before and after adsorption revealed that ion exchange was the main mechanism involved. The BET surface area of the composite adsorbent was 55.30 m^2/g. Meanwhile, negative values of zeta potential showed promising results for the adsorption process. The best conditions for the effective adsorption of colour, COD and NH_3-N from natural rubber wastewater onto composite adsorbents were found to be 3g of adsorbent pH 7, 150 rpm shaking speed and 100 min contact time. The maximum removal of colour, COD and NH_3-N using composite adsorbents from natural rubber wastewater was 98%, 87.2% and 94.2% respectively. The investigation of adsorption isotherms model showed that the adsorption isotherm data fitted well to the Langmuir isotherm. This indicated that the monolayer coverage on the composite adsorbent was dominant. On the other hand, the adsorption kinetics complied well with the pseudo-second-order kinetic model which indicated that the rate of the sorption reaction was controlled by the second-order mechanism (chemisorption). Column adsorption demonstrated that the removal of colour, COD and NH_3-N can reach up to 99.99% at a lower flow rate of 2 ml/min which results in a longer breakthrough and exhaustion time. Meanwhile, the experiment data was found to comply well with the Thomas and Yoon-Nelson model rather compared to the Adam-Bohart model. The regeneration study achieved three (3) adsorption cycles of the spent composite adsorbent. In conclusion, the present study was able to prove that composite adsorbent is a promising adsorbent for the removal of colour, COD and NH_3-N from natural rubber wastewater.

ABSTRAK

Pembangunan bahan penjerap komposit merupakan kaedah baru dalam aplikasi rawatan air sisa. Gabungan beberapa bahan penjerap terbukti mampu menyingkirkan bahan pencemar serentak berbanding dengan satu bahan penjerap sahaja. Tujuan kajian ini adalah untuk menghasilkan bahan penjerap komposit dari zeolit semulajadi, tandan kosong kelapa sawit (EFB) serta kaolin dan diikat menggunakan kitosan untuk menjerap warna, permintaan oksigen kimia (COD) dan ammonia nitrogen (NH_3-N) dari air sisa getah asli. Kaedah penjerapan kelompok dan turus lapisan tetap digunakan dalam kajian ini. Nisbah gabungan zeolit, EFB dan kaolin sebagai komposit ditentukan menggunakan kaedah reka bentuk campuran D-optimal (DMD), manakala pencirian bahan penjerap komposit dibuat menggunakan spektroskopi Inframerah (FTIR), mikroskop elektron pengimbas pancaran medan (FESEM), Brunauer-Emmett-Teller (BET) dan keupayaan zeta. Ujian kelompok dijalankan untuk menentukan pengaruh pelbagai faktor iaitu dos bahan penjerap, pH, kelajuan goncangan dan sentuhan masa bagi penjerapan warna, COD dan NH_3-N oleh bahan penjerap komposit. Model Langmuir dan Freundlich digunakan untuk menyiasat isoterma penjerapan, manakala pseudo-tertib pertama, pseudo-tertib kedua, pembauran intra-partikel dan Elovich untuk meneliti sifat kinetik. Prestasi penjerapan lapisan tetap dinilai dengan mempelbagaikan kadar aliran influen (2, 2.5 dan 3 mL/min), manakala kinetik penjerapan dianalisa menggunakan model kinetik Thomas, Yoon-Nelsoon dan Adam-Bohart. Penjanaan semula bahan penjerap komposit untuk sehingga lima pusingan penjerapan/penyaherapan juga disiasat. Berdasarkan keputusan, komposisi zeolit 0.4g, kaolin 0.8g EFB and 0.8g ialah nisbah terbaik dalam penyingkiran warna, COD dan NH_3-N dari air sisa getah asli. Analisis FTIR dan FE-SEM sebelum dan selepas penjerapan mendedahkan bahawa penukaran ion ialah mekanisma utama yang terlibat. Luas permukaan BET bahan penjerap komposit ialah 55.30 m^2/g. Sementara itu, nilai negatif keupayaan zeta menunjukkan potensi dalam proses penjerapan. Keadaan terbaik untuk pernjerapan warna, COD, NH_3-N yang berkesan dari air sisa getah asli

oleh bahan penjerap komposit adalah 3g bahan penjerap, pH 7, kelajuan goncangan 150 rpm dan 100 min sentuhan masa. Penyingkiran maksimum bagi warna, COD dan NH_3-N menggunakan bahan penjerap komposit dari air sisa getah asli masing-masing ialah 98%, 87.2% dan 94.2%. Siasatan model isoterma penjerapan menunjukkan bahawa data isoterma penjerapan sesuai dengan isoterma Langmuir. Ini menunjukkan bahawa liputan ekalapisan pada bahan penjerap komposit adalah dominan. Sebaliknya, kinetik penjerapan menunjukkan pematuhan yang baik untuk model pseudo-tertib kedua yang menunjukkan bahawa kadar tindak balas jerapan yang dikawal oleh mekanisma tertib kedua (penjerapan kimia). Penjerapan turus menunjukkan bahawa penyingkiran warna, COD dan NH_3-N boleh mencapai sehingga 99.99% pada kadar aliran rendah 2 mL/min yang menghasilkan penyingkiran parameter yang lebih baik dan tempoh keletihan yang lebih perlahan. Sementara itu, data uji kaji didapati mematuhi model Thomas dan Yoon-Nelson berbanding dengan model Adam-Bohart. Analisa penjerapan/penyaherapan telah mencapai tiga (3) kitaran kebolehgunaan bahan penjerap komposit. Kesimpulannya, kajian ini telah membuktikan bahwa bahan penjerap komposit adalah bahan penjerap yang berpotensi dalam penyingkiran warna, COD dan NH_3-N dari air sisa getah asli.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

C	-	Solute/outlet concentration
C_b	-	Effluent concentration
C_{ad}	-	Different between inlet/initial and outlet equilibrium concentration
C_{de}	-	The concentration of adsorbate desorbed
C_e	-	Concentration of adsorbate at equilibrium
C_i	-	Constant for Intra-particle diffusion model
C_t	-	The concentration of adsorbate at the time, t
C_O	-	Initial/inlet adsorbate concentration
K_F	-	Adsorption or distribution coefficient for Freundlich isotherm
K_L	-	The rate of adsorption for Langmuir isotherm
k_{pi}	-	Adsorption rate constant for intra-particle diffusion model
k_1	-	Adsorption rate constant for pseudo-first-order
k_2	-	Adsorption rate constant for pseudo-second-order
NH_3-N	-	Ammonia nitrogen
n	-	Constant for Freundlich isotherm
pH_{pzc}	-	Point of zero potential
Q_o	-	Adsorption capacity for Langmuir isotherm
q_e	-	Amount of adsorbate adsorbed per unit mass of adsorbent at equilibrium
q_t	-	Amount of adsorbate adsorbed per unit mass of adsorbent at the time, t
q_t, cal	-	Calculated adsorption uptake at the time, t
q_t, exp	-	Experimental adsorption uptake at the time, t
R_L	-	Separation factor
R^2	-	Coefficient of determination
S_{BET}	-	BET surface area
T	-	Time

V_{meso}	-	Mesopore volume
V_T	-	Total pore volume

LIST OF ABBREVIATION

ANOVA	-	Analysis of variance
APHA	-	American Public Association
BET	-	Brunauer-Emmett-Teller
CH_3COOH	-	Acetic Acid
EBCT	-	Empty Bed Contact Time
EFB	-	Empty Fruit Bunch
FTIR	-	Fourier Transform Infrared
MTZ	-	Mass Transfer Zone
NH_3-N	-	Ammoniacal Nitrogen
RO	-	Reverse Osmosis
SEM	-	Scanning Electron Microscopy
XRD	-	X rays Diffraction
XRF	-	X ray Fluorescence

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Malaysia is the fourth biggest rubber manufacturer in the world after Thailand, Indonesia and India. Rubber industry is one of the most important industries and plays a vital role in the Malaysia economy (Mokhtar *et al.*, 2015; Vijayaraghavan *et al.*, 2008). Natural rubber is an important raw material for production of more than 40,000 consumer products such as conveyor belts, rubber rollers and others, automotive products (fan belts, radiator hoses and others), latex products (rubber gloves, toys hygienic products) and many kinds of adhesives tires (major consumer), shoes, gloves and also medical devices (Nazri *et al.*, 2015; Pillai & Girish, 2014).

The raw material for natural rubber production is white fluid called 'Latex' which is obtained from *rubber Hevea Brasiliensis* trees (Ashok *et al.*, 2015). There are two types of processes in raw natural rubber processing which are; the production of concentrated natural rubber latex (NRL) and the standard Malaysian rubber (Mokhtar *et al.*, 2015). However, the production process of the rubber industry always leads to generate of a large amount of contaminated wastewater, as a result from a large quantity of water needed during processing (Mokhtar *et al.*, 2015; Pillai & Girish, 2014).

Rubber-processing industries generate wastewater in the range of 10 to 30 L/kg of raw material. This wastewater includes wash water, small amounts of uncoagulated latex, and serum with small quantities of protein, carbohydrates, lipids, carotenoids, and salts (Ashok *et al.*, 2015; Nazri *et al.*, 2015; Pillai & Girish, 2014). In general, rubber wastewater has a high concentration of NH_3-N, BOD, COD, nitrate, phosphorus and total solids (Rosman *et al.*, 2014; Kumlanghan *et al.*, 2008). The characteristics of natural rubber wastewater as follows: pH, 3.7 to 5.5; total suspended solids (TSS), 200 to 700 mg/L; biochemical oxygen demand (BOD5), 1500 to 700 mg/L; and chemical oxygen demand (COD), 3500 to 14000 mg/L; total nitrogen (TN), 200 to 1800 mg/L and sulphate, 500 to 2000 mg/L (Mokhtar *et al.*, 2015).

High level of nitrogen and ammonia wastewater is discharged directly into surface waters wells, streams, lakes or even the sea, which will inevitably pollute the water. The discharge of these effluents into public water bodies can give rise to serious depletion of dissolved oxygen, thus affecting the normal environment supporting the aquatic system and lead to the death of some aquatic organisms living in the water (Pillai & Girish, 2014; Rosman *et al.*, 2014). Therefore, treatment of rubber wastewater using effective technologies for overcoming these problems is needed (Smitha *et al.*, 2012).

Environmental Quality (Industrial Effluents) Regulations 2009 under standard A and standard B is stringent environmental regulation for the control of rubber effluents which is enforced in Malaysia. Standard A for discharge upstream of any raw water intake, and standard B for discharge downstream of any raw water intake (Mamun & Zainudin, 2013). Each wastewater treatment plant must comply with these standards. Both standards consist of discharge temperature, pH, biological oxygen demand (BOD), chemical oxygen demand (COD), suspended solids (SS) and other heavy metals, but with different parameter limits (Mokhtar *et al.*, 2015).

Several technologies have been developed to treat natural rubber wastewater including such as anaerobic-cum-facultative lagoon system, anaerobic-cum-aerated lagoon system, aerated lagoon system and oxidation ditch system, aerobic granular sludge technology (Rosman *et al.*, 2014; Rosman *et al.*, 2013; Xin *et al.*, 2013; Abdullah & Sulaiman, 2013). However, these systems are inefficient for the removal of recalcitrant organics and micro-pollutants in natural rubber wastewater (Ashok *et al.*, 2015). In addition, these systems required large space, longer effluent treatment period, odour problems, high operating, and maintenance costs. These circumstances lead to frequent non-compliance with the legal discharge limits (Rosman *et al.*, 2014).

Therefore, the need to find effective and economical alternative techniques is taken as a priority in the water and wastewater treatment industry (Simate & Ndlovu, 2015; Barakat, 2011). Recently, adsorption has become one of the successful alternative treatments of wastewater (Barakat, 2011; Wan Ngah *et al.*, 2011). Adsorption is considered to be an efficient and versatile method, due to various adsorbents having good selectivity toward different types of wastewater,

REFERENCES

Abas, S. N. A., Ismail, M. H. S., Kamal, M. L., & Izhar, S. (2013). Adsorption Process of Heavy Metals by Low-Cost Adsorbent : A Review. *World Applied Sciences Journal 28*, *28*(11), 1518–1530.

Abdel-Ghani, N. T., & El-Chaghaby, G. A. (2014). Biosorption for metal ions removal from aqueous solutions:: A review of recent studies. *International Journal of Latest Research in Science and Technology*, *3*(1), 24–42.

Abdolali, a, Guo, W. S., Ngo, H. H., Chen, S. S., Nguyen, N. C., & Tung, K. L. (2014). Typical lignocellulosic wastes and by-products for biosorption process in water and wastewater treatment: a critical review. *Bioresource Technology*, *160*, 57–66.

Abdullah, N. A. H., Bakar, B., Kamaludin, N. H. I., Tompang, M. F., & Arbain, D. (2015). Statistical optimization of Aspergillus Oryzae growth for bioremediation of industrial natural rubber effluent serum. *International Journal of Applied Engineering Research*, *10*(November), 64–68.

Abdullah, N., & Sulaiman, F. (2013). The oil palm wastes in Malaysia. *Biomass Now – Sustainable Growth and Use The*, (3), 75–100.

Abdullah, N., & Sulaiman, F. (2013). The properties of the washed empty fruit bunches of oil palm. *Journal of Physical Science*, *24*(2), 117–137.

Abraham, V. T., Radhakrishnan Nair, N., & Madhu, G. (2009). Electrochemical treatment of skim serum effluent from natural rubber latex centrifuging units. *Journal of Hazardous Materials*, *167*(1–3), 494–499.

Adegoke, K. A., & Bello, O. S. (2015). Dye sequestration using agricultural wastes as adsorbents. *Water Resources and Industry*, *12*, 8–24.

Aguilera, P. G., & Gutiérrez Ortiz, F. J. (2016). High performance regenerative adsorption of hydrogen sulfide from biogas on thermally-treated sewage-sludge. *Fuel Processing Technology*, *145*, 148–156.

Ahmad, A. A., & Hameed, B. H. (2009). Reduction of COD and color of dyeing effluent from a cotton textile mill by adsorption onto bamboo-based activated carbon. *Journal of Hazardous Materials*, *172*(2–3), 1538–1543.

Ahmaruzzaman, M. (2011). Industrial wastes as low-cost potential adsorbents for the treatment of wastewater laden with heavy metals. *Advances in Colloid and Interface Science*, *166*(1–2), 36–59.

Akazdam, S., Chafi, M., Yassine, W., Sebbahi, L., Gourich, B., & Barka, N. (2017). Decolourization of cationic and anionic dyes from aqueous solution by adsorption on NaOH treated eggshells : Batch and fixed bed column study using response surface methodology. *Journal of Materials and Environmental Sciences*, *8*(3), 784–800.

Akpor, O. B., Muchie, M. (2011). Environmental and public health implications of wastewater quality. *African Journal of Biotechnology*, *10*(13), 2379–2387.

Alam, M. Z., Ameem, E. S., Muyibi, S. A., & Kabbashi, N. A. (2009). The factors affecting the performance of activated carbon prepared from oil palm empty fruit bunches for adsorption of phenol. *Chemical Engineering Journal*, *155*(1–2), 191–198.

Alam, M. Z., Mamun, A. A., Qudsieh, I. Y., Muyibi, S. A., Salleh, H. M., & Omar, N. M. (2009). Solid state bioconversion of oil palm empty fruit bunches for cellulase enzyme production using a rotary drum bioreactor. *Biochemical Engineering Journal*, *46*(1), 61–64.

Ali, I., Asim, M., & Khan, T. A. (2012). Low cost adsorbents for the removal of organic pollutants from wastewater. *Journal of Environmental Management*, *113*, 170–183.

Aluyor, E. O., & Badmus, O. a M. (2008). COD removal from industrial wastewater using activated carbon prepared from animal horns. *African Journal of Biotechnology*, *7*(21), 3887–3891.

Anah, L., & Astrini, N. (2017). Technical and economic assessment of the implementation of measures for reducing energy losses in distribution systems. In *IOP Conf. Series: Earth and Environmental Science* (Vol. 73, pp. 1–6).

APHA. (2012). *Standard Methods for the Examination of Water and Wastewater: American Public Health Association, AWWA (American Water Works Association)*.

Arias, F., & Sen, T. K. (2009). Removal of zinc metal ion (Zn2+) fromits aqueous solution by kaolin clay mineral: A kinetic and equilibrium study. *Colloids and Surfaces A: Physicochem. Eng. Aspects*, *348*, 100–108.

Arseenin, H. R. (2015). *Adsorption of arsenic from ammonia containing waste water by ferrous*. Lappeenranta University of Technology: Master Thesis.

Arslan, A., & Veli, S. (2012). Zeolite 13X for adsorption of ammonium ions from aqueous solutions and hen slaughterhouse wastewaters. *Journal of the Taiwan Institute of Chemical Engineers*, *43*(3), 393–398.

Asadi, F., Shariatmadari, H., & Mirghaffari, N. (2008). Modification of rice hull and sawdust sorptive characteristics for remove heavy metals from synthetic solutions and wastewater. *Journal of Hazardous Materials*, *154*(1–3), 451–8.

Asghar, H. M. A., Hussain, S. N., Brown, N. W., & Roberts, E. P. L. (2014). Synthesis of electrically conducting composite adsorbents for wastewater treatment using adsorption & electrochemical regeneration. *Journal of Industrial and Engineering Chemistry*, *20*(3), 781–786.

Ashok, L., Adishkumar, S., Rajesh Banu, J., & Yeom, I. T. (2015). Ferrioxalate-induced solar photo-fenton treatment of natural rubber latex wastewaters. *Water Quality Research Journal of Canada*, *50*(4), 349–358.

Au, P. I., & Leong, Y. K. (2013). Rheological and zeta potential behaviour of kaolin and bentonite composite slurries. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, *436*, 530–541.

Auta, M. (2012). Fixed bed adsorption Studies of Rhodamine B dye using oil palm empty fruits bunch activated carbon. *Journal of Engineering Research and Studies*, *Vol. III*(III), 03–06.

Auta, M., & Hameed, B. H. (2012). Modified mesoporous clay adsorbent for adsorption isotherm and kinetics of methylene blue. *Chemical Engineering Journal*, *198–199*, 219–227.

Auta, M., & Hameed, B. H. (2014). Chitosan – clay composite as highly effective and low-cost adsorbent for batch and fixed-bed adsorption of methylene blue. *Chemical Engineering Journal*, *237*, 352–361.

Auta, M., Jibril, M., Tamuno, P. B. L., Alechenu, A., International, A., Auta, M., … Alechenu, A. (2012). Preparation of activated carbon from oil palm fruit bunch for the adsorption of Acid Red 1 using optimized Response surface methodology. *Journal of Engineering Research and Applications (IJERA)*, *2*(3), 1805–1815.

Aydm, F., & Kuleyin, A. (2011). The effect of modification and initial concentration on ammonia removal from leachate by zeolite. *World Academy of Science, Engineering and Technology*, *5*(6), 226–229.

Aysan, H., Edebali, S., Ozdemir, C., Celik Karakaya, M., & Karakaya, N. (2016). Use of chabazite, a naturally abundant zeolite, for the investigation of the adsorption kinetics and mechanism of methylene blue dye. *Microporous and Mesoporous Materials*, *235*, 78–86.

Aziz, B. K., & Shareef, F. H. (2013). Using natural clays and spent bleaching clay as cheap adsorbent for the removal of phenol in aqueous media. *International Journal of Basic & Applied Sciences*, *13*(2), 45–49.

Aziz, H. A., Foul, A. A., Isa, M. H., & Hung, Y. T. (2010). Physico-chemical treatment of anaerobic landfill leachate using activated carbon and zeolite: batch and column studies. *International Journal of Environment and Waste Management*, *5*(3/4), 269.

Aziz, H. A., Hin, L. T., Adlan, M. N., Zahari, M. S., Alias, S., Ahmed, A. M., … Umar, M. (2011). Removal of high-strength colour from semi-aerobic stabilized landfill leachate via adsorption on limestone and activated carbon mixture. *Research Journal of Chemical Sciences*, *1*(6), 1–7.

Azreen, I., Lija, Y., & Zahrim, A. Y. (2017). Ammonia nitrogen removal from aqueous solution by local agricultural wastes. *IOP Conference Series: Materials Science and Engineering*, *206*(Ii), 12077.

Baqir, S. J., & Halbus, A. F. (2014). Removal reactive blue dye from wastewater by adsorption on white Iraqi kaolin clay : ةصلاخلا. *Journal of Babylon University/Pure and Applied Sciences*, (7), 1947–1956.

Barakat, M. a. (2011). New trends in removing heavy metals from industrial wastewater. *Arabian Journal of Chemistry*, *4*(4), 361–377.

Bashir, M. J. K., Cheong, C. C., Aun, N. C., & Amr, S. S. A. (2014). Equilibrium modeling and kinetic studies on the adsorption of basic dye by a low- Cost adsorbent : sugarcane bagasse. *International Journal of Scientific Research in Environmental Sciences*, *2*(8), 301–307.

Bekçi, Z., Özveri, C., Seki, Y., & Yurdakoç, K. (2008). Sorption of malachite green on chitosan bead. *Journal of Hazardous Materials*, *154*(1–3), 254–261.

Benhouria, A., Islam, M. A., Zaghouane-Boudiaf, H., Boutahala, M., & Hameed, B. H. (2015). Calcium alginate-bentonite-activated carbon composite beads as highly effective adsorbent for methylene blue. *Chemical Engineering Journal*, *270*, 621–630.

Bernard, E., Jimoh, A., & Odigure, J. O. (2013). Heavy metals removal from industrial wastewater by activated carbon prepared from coconut shell. *Reasearch Journal of Chemical Scieences*, *3*(8), 3–9.

Beyene, H. D. (2014). The potential of dyes removal from textile wastewater by using different treatment technology, a review. *International Journal of Environmental Monitoring and Analysis*, *2*(6), 347–353.

Bhatnagar, A., & Sillanpää, M. (2010). Utilization of agro-industrial and municipal waste materials as potential adsorbents for water treatment—A review. *Chemical Engineering Journal*, *157*(2–3), 277–296.

Bhattacharyya, K. G., & Gupta, S. Sen. (2006). Kaolinite, montmorillonite, and their modified derivatives as adsorbents for removal of Cu(II) from aqueous solution. *Separation and Purification Technology*, *50*(3), 388–397.

Biswas, S., & Mishra, U. (2015). Continuous fixed-bed column study and adsorption modeling: Removal of lead ion from aqueous solution by charcoal originated from chemical carbonization of rubber wood sawdust. *Journal of Chemistry*, *2015*, 1–9.

Borhan, F. P., Abd Gani, S. S., & Shamsuddin, R. (2014). The use of D-optimal mixture design in optimising okara soap formulation for stratum corneum application. *Scientific World Journal*, *2014*(May 2015).

Borhan, F. P., Gani, S. S. A., & Shamsuddin, R. (2014). The use of D-optimal mixture design in optimising okara soap formulation for stratum corneum application. *Scientific World Journal*, *2014*.

Boukhemkhem, A., & Rida, K. (2017). Improvement adsorption capacity of methylene blue onto modified Tamazert kaolin. *Adsorption Science and Technology*, *35*(9–10), 753–773.

Bu, X., Evans, G., Xie, G., Peng, Y., Zhang, Z., Ni, C., & Ge, L. (2017). Removal of fine quartz from coal-series kaolin by flotation. *Applied Clay Science*, *143*(April), 437–444.

Bulut, Y., & Karaer, H. (2015). Adsorption of methylene blue from aqueous solution by crosslinked chitosan/bentonite composite. *Journal of Dispersion Science and Technology*, *36*(1), 61–67.

Canteli, A. M. D., Carpine, D., Scheer, A. D. P., Mafra, M. R., & Mafra, L. I. (2014). Fixed-bed column adsorption of the coffee aroma compound benzaldehyde from aqueous solution onto granular activated carbon from coconut husk. *Food Science and Technology Journal*, *59*.

Caponi, N., Collazzo, G. C., Dotto, G. L., Mazutti, A., Foletto, E. L., Maria, S., & Green, M. (2017). Use of Brazilian kaolin as a potential low-cost adsorbent for the removal of malachite green from colored effluents. *Materials Research*, 1–9.

Cetinus, S. A., Sahin, E., & Saraydin, D. (2009). Preparation of Cu (II) adsorbed chitosan beads for catalase immobilization. *Food Chemistry*, *114*, 962–969.

Chagas, N. V., Quinaia, S. P., Anaissi, F. J., Santos, J. M., Felsner, M. L., & Justi, K. C. (2013). Clay and charcoal composites: characterisation and application of factorial design analysis for dye adsorption. *Chemical Papers*, *68*(4), 553–563.

Cheng, Q., Li, H., Xu, Y., Chen, S., Liao, Y., Deng, F., & Li, J. (2017). Study on the adsorption of nitrogen and phosphorus from biogas slurry by NaCl-modified zeolite. *PLoS ONE*, *12*(5), 1–12. https://doi.org/10.1371/journal.pone.0176109

Chowdhury, Z. Z., Zain, S. M., Khan, R. A., Ahmad, A. A., & Islam, M. S. (2011). Application of central composite design for preparation of Kenaf fiber based activated carbon for adsorption of manganese (II) ion. *International Journal of the Physical Sciences*, *6*(1).

Crini, G., & Badot, P.-M. (2010). Starch-based biosorbents for dyes in textile wastewater treatment. *Int. J. Environmental Technology and Management*, *1234*(2), 129–150.

Dawodu, F. A., & Akpomie, K. G. (2014). Simultaneous adsorption of Ni(II) and Mn(II) ions from aqueous solution unto a Nigerian kaolinite clay. *Journal of Materials Research and Technology*, *3*(2), 129–141.

Demirbas, A. (2008). Heavy metal adsorption onto agro-based waste materials: a review. *Journal of Hazardous Materials*, *157*(2–3), 220–229.

Deng, L., & Shi, Z. (2015). Synthesis and characterization of a novel Mg–Al hydrotalcite-loaded kaolin clay and its adsorption properties for phosphate in aqueous solution. *Journal of Alloys and Compounds*, *637*, 188–196.

Deng, L., Shi, Z., Luo, L., Chen, S., Yang, L., Yang, X., & Liu, L. (2014). Adsorption of hexavalent chromium onto kaolin clay based adsorbent. *Journal of Central South University*, *21*(10), 3918–3926.

Deniz, F., & Ersanli, E. T. (2016). Removal of colorant from simulated wastewater by phyco-composite material: Equilibrium, kinetic and mechanism studies in a lab-scale application. *Journal of Molecular Liquids*, *220*(May), 120–128.

Dincer, A., Becerik, S., & Aydemir, T. (2012). Immobilization of tyrosinase on chitosan – clay composite beads. *International Journal of Biological Macromolecules*, *50*, 815–820.

Dong, S., & Sartaj, M. (2016). Statistical analysis and optimization of ammonia removal from landfill leachate by sequential microwave/aeration process using factorial design and response surface methodology. *Journal of Environmental Chemical Engineering*, *4*(1), 100–108.

Dotto, G. L., Rodrigues, F. K., Tanabe, E. H., Fröhlich, R., Bertuol, D. A., Martins, T. R., & Foletto, E. L. (2016). Development of chitosan/bentonite hybrid composite to remove hazardous anionic and cationic dyes from colored effluents. *Journal of Environmental Chemical Engineering*, *4*(3), 3230–3239.

El-Geundi, M. S., Ashour, E. A., Abobeah, R. M. A., & Shehata, N. (2014). Determination of specific surface area of natural clay by comparative methods. *International Journal of Science, Engineering and Technology Research (IJSETR)*, *3*(8).

Elmoubarki, R., Mahjoubi, F. Z., Tounsadi, H., & Moustadraf, J. (2015). Adsorption of textile dyes on raw and decanted Moroccan clays : Kinetics , equilibrium and thermodynamics. *Water Resources and Industry*, *9*, 16–29.

Ersoy, B., Evcin, A., Uygunoglu, T., Akdemir, Z. B., Brostow, W., & Wahrmund, J. (2014). Zeta Potential-Viscosity relationship in kaolinite slurry in the presence of dispersants. *Arabian Journal for Science and Engineering*, *39*(7), 5451–5457.

Fagbenro, O. K., & Aziz, H. A. (2015). Preparation and particle size effect of clinoptilolite on the removal of color , suspended solids , and chemical oxygen demand from real textile wastewater. *Desalination and Water Treatment*, *3994*(September).

Fawzy, M., Nasr, M., Helmi, S., & Nagy, H. (2016). Experimental and theoretical approaches for Cd(II) biosorption from aqueous solution using Oryza sativa biomass. *International Journal of Phytoremediation*, *18*(11), 1096–1103.

Foo, K. Y., & Hameed, B. H. (2010). Decontamination of textile wastewater via TiO 2 / activated carbon composite materials. *Advances in Colloid and Interface Science*, *159*(2), 130–143.

Franco, M. A. E., Carvalho, C. B., Bonetto, M. M., Soares, R. de P., & Feris, L. A. (2017). Removal of amoxicillin from water by adsorption onto activated carbon in batch process and fixed bed column: Kinetics, isotherms, experimental design and breakthrough curves modelling. *Journal of Cleaner Production*, *161*, 947–956.

Gandhi, M. R., & Meenakshi, S. (2012). International Journal of Biological Macromolecules Preparation and characterization of silica gel / chitosan composite for the removal of Cu (II) and Pb (II). *International Journal of Biological Macromolecules*, *50*(3), 650–657.

Gaouar Yadi, M., Benguella, B., Gaouar-Benyelles, N., & Tizaoui, K. (2015). Adsorption of ammonia from wastewater using low-cost bentonite/chitosan beads. *Desalination and Water Treatment*, *3994*(June), 1–11.

Ghani, Z. A., Yusoff, M. S., Zaman, N. Q., Zamri, M. F. M. A., & Andas, J. (2017). Optimization of preparation conditions for activated carbon from banana pseudo-stem using response surface methodology on removal of color and COD from landfill leachate. *Waste Management*, *62*, 177–187.

Ghorai, S., Sarkar, A. K., Panda, a B., & Pal, S. (2013). Effective removal of Congo red dye from aqueous solution using modified xanthan gum/silica hybrid nanocomposite as adsorbent. *Bioresource Technology*, *144*, 485–91.

Girish, K. (2014). Effect of Carbon Sources on the Biomass Build-Up and Degradation of Rubber Processing Industry Effluent. *International Journal of Applied Sciences and Biotechnology*, *2*(4), 579–584.

Golie, W. M., & Upadhyayula, S. (2016). Continuous fixed-bed column study for the removal of nitrate from water using chitosan/alumina composite. *Journal of Water Process Engineering*, *12*, 58–65.

Gong, J.-L., Zhang, Y.-L., Jiang, Y., Zeng, G.-M., Cui, Z.-H., Liu, K., … Huan, S.-Y. (2015). Continuous adsorption of Pb(II) and methylene blue by engineered graphite oxide coated sand in fixed-bed column. *Applied Surface Science*, *330*, 148–157.

Grassi, M., Kaykioglu, G., & Belgiorno, V. (2012). Emerging compounds removal from wastewater. *Natural and Solar Based Treatments*, 15–38.

Guizhen, F., Hong, L., & Wenqi, G. (2011). Study on preparation of composite materials of montmorillonite. *International Journal of Material Science*, *1*, 18–22.

Halim, A. A., Aziz, H. A., Johari, M. A. M., Ariffin, K. S., & Adlan, M. N. (2010). Ammoniacal nitrogen and COD removal from semi-aerobic landfill leachate using a composite adsorbent: fixed bed column adsorption performance. *Journal of Hazardous Materials*, *175*(1–3), 960–4.

Halim, A. A., Han, K. K., & Hanafiah, M. M. (2015). Removal of Methylene Blue from Dye Wastewater Using River Sand by Adsorption. *Nature Environment and Pollution Technology*, *14*(1), 1–6.

Halim, A. A., Latif, M. T., & Ithnin, A. (2013). Ammonia removal from aqueous solution using Organic acid modified activated carbon. *World Applied Sciences Journal*, *24*(1), 1–6.

Halim, A., Abidin, N., Awang, N., Ithnin, A., Othman, M., & Wahab, M. (2011). Ammonia and cod removal from synthetic leachate using rice husk composite adsorbent. *Journal of Urban and Environmental Engineering*, *5*(1), 24–31.

Hameed, K. S., Muthirulan, P., & Sundaran, M. M. (2017). Adsorption of chromotrope dye onto activated carbons obtained from the seeds of various plants: Equilibrium and kinetics studies. *Arabian Journal of Chemistry*, *10*, S2225–S2233.

Hanafiah, M. A. K. M., Ngah, W. S. W., & Safuan, N. M. (2015). Removal of acid Violet 7 using chitosan-GLA as the adsorbent. *American Journal of Environmental Engineering*, *5*, 13–18.

Haseena, P. V., Padmavathy, K. S., Krishnan, P. R., & Madhu, G. (2016). Adsorption of ammonium nitrogen from aqueous systems using chitosan-bentonite film composite. *Procedia Technology*, *24*, 733–740.

Hassan, A. F., Abdel-Mohsen, A. M., & Fouda, M. M. G. (2014). Comparative study of calcium alginate, activated carbon, and their composite beads on methylene blue adsorption. *Carbohydrate Polymers*, *102*(1), 192–198.

Hesas, R. H., Arami-Niya, A., Wan Daud, W. M. A., & Sahu, J. N. (2013). Preparation and characterization of activated carbon from apple waste by microwave-assisted phosphoric acid activation: Application in methylene blue adsorption. *BioResources*, *8*(2), 2950–2966.

Hidayu, A. R., Mohamad, N. F., Matali, S., & Sharifah, A. S. a. K. (2013). Characterization of activated carbon prepared from oil palm empty fruit bunch using BET and FT-IR Techniques. *Procedia Engineering*, *68*, 379–384.

Hosseini, N. S., & Fatemi, S. (2013). Experimental study and adsorption modeling of COD reduction by activated carbon for wastewater treatment of oil refinery. *Iranian Journal of Chemistry and Chemical Engineering*, *32*(3), 81–89.

Hou, H., Zhou, R., Wu, P., & Wu, L. (2012). Removal of Congo red dye from aqueous solution with hydroxyapatite/chitosan composite. *Chemical Engineering Journal*, *211–212*, 336–342.

Howard, R. L., Abotsi, E., L, J. V. R. E., & Howard, S. (2003). Lignocellulose biotechnology : issues of bioconversion and enzyme production. *African Journal of Biotechnology*, *2*(December), 602–619.

Hu, P., Wang, J., & Huang, R. (2016). Simultaneous removal of Cr(VI) and Amido black 10B (AB10B) from aqueous solutions using quaternized chitosan coated bentonite. *International Journal of Biological Macromolecules*, *92*(Vi), 694–701.

Huang, H., Xiao, X., Yan, B., & Yang, L. (2010). Ammonium removal from aqueous solutions by using natural Chinese (Chende) zeolite as adsorbent. *Journal of Hazardous Materials*, *175*(1–3), 247–252.

Huang, Y., Bai, Y., Wang, Y., & Kong, H. (2014). Solidago canadensis L. extracts to control algal (Microcystis) blooms in ponds. *Ecological Engineering*, *70*, 263-267.

Huang, Y., Hu, Y., Chen, L., Yang, T., Huang, H., Shi, R., … Zhong, C. (2018). Selective biosorption of thorium (IV) from aqueous solutions by ginkgo leaf. *PLOS ONE*, (Iv), 1–25.

Ibrahim, A., Yusof, L., Beddu, N. S., Galasin, N., Lee, P. Y., Lee, R. N. S., & Zahrim, A. Y. (2016). Adsorption study of ammonia nitrogen by watermelon rind. *IOP Conference Series: Earth and Environmental Science*, *36*(1).

Isa, M. H., Ibrahim, N., Aziz, H. A., Adlan, M. N., Sabiani, N. H. M., Zinatizadeh, A. A. L., & Kutty, S. R. M. (2008). Removal of chromium (VI) from aqueous solution using treated oil palm fibre. *Journal of Hazardous Materials*, *152*(2), 662–668.

Ismail, M. H. S., Dalang, S., Syam, S., & Izhar, S. (2013). A study on zeolite performance in waste treating ponds for treatment of palm oil mill effluent. *Journal of Water Resource and Protection*, *5*(7), 18–27.

Ismail, S., & Yaacob, Z. (2011). Properties of laterite brick reinforced with oil palm empty fruit bunch fibres. *Pertanika Journal of Science and Technology*, *19*(1), 33–43.

Iyagba, M., Adoki, A., & Sokari, T. (2008). Testing biological methods to treat rubber effluent. *African Journal of Agricultural Research*, *3*(6), 448–454.

Jamil, T. S., Ibrahim, H. S., & El-maksoud, I. H. A. (2010). Application of zeolite prepared from Egyptian kaolin for removal of heavy metals : I . Optimum conditions. *Desalination*, *258*(1–3), 34–40.

Ji, G., Bao, W., Gao, G., An, B., Zou, H., & Gan, S. (2012). Removal of Cu (II) from Aqueous Solution Using a Novel Crosslinked. *Chinese Journal of Chemical Engineering*, *20*(4), 641–648.

Jintakosol, T., & Nitayaphat, W. (2016). Adsorption of silver (I) from aqueous solution using chitosan/montmorillonite composite beads. *Materials Research*, *19*(5), 1114–1121.

Joseph, C. G., Daud, W. M. A. W., Shane, Q. K., & Sanmugam, K. (2015). Parametric and adsorption kinetic studies of reactive black 5 removal from textile simulated wastewater using oil palm (Elais guineensis) eEmpty fruit bunch. *Journal of Applied Sciences*, *15*(8), 1103–1111.

Kadir, A. A., Mustafa, M., Bakri, A., Sandu, A. V., Noor, N. M., Lisanah, A., … Hussin, K. (2014). Usage of palm shell activated carbon to treat landfill leachate. *International Journal of Conservation Science*, *5*(1), 117–126.

Kaman, S., Tan, I., & Lim, L. (2017). Palm oil mill effluent treatment using coconut shell–based activated carbon: Adsorption equilibrium and isotherm. *MATEC Web of Conferences*, *87*, 3009.

Kamaruddin, M. A. (2015). Development of Carbon Mineral Composite Adsorbent. *PhD Thesis, Universiti Sains Malaysia*, Unpublished.

Kamaruddin, M. A., Yusoff, M. S., Aziz, H. A., & Alrozi, R. (2013). Preparation of rice husk carbon-clinoptilolite composite adsorbent for color removal from real textile wastewater: Effects of operating conditions. *2013 IEEE Business Engineering and Industrial Applications Colloquium (BEIAC)*, 494–499.

Kamaruddin, M. A., Yusoff, M. S., Aziz, H. A., & Alrozi, R. (2014). Preparation and Characterization of Activated Carbon Embedded Clinoptilolite Adsorbent for Colour Removal from Textile Effluent. *Journal of Material and Chemical Engineering*, *2*, 1–10.

Kamaruddin, M. A., Yusoff, M. S., Aziz, H. A., & Ismail, M. N. (2013). Preparation and Characterization of Composite Embedded Clinoptilolite for the Removal of Color and Lead from Textile Waste Water. *International Journal of Scientific Research in Inventions and New Ideas*, *1*(2), 37–47.

Kasim, F., & Kasim, A. (2013). Hydrolysis of oil palempty fruit bunch fibers to produce sugar hydrolyzate as raw material for bioethanol production. *International Journal on Advanced Science*, *3*(3), 24–27.

Katsou, E., Malamis, S., Tzanoudaki, M., Haralambous, K. J., & Loizidou, M. (2011). Regeneration of natural zeolite polluted by lead and zinc in wastewater treatment systems. *Journal of Hazardous Materials*, *189*(3), 773–786.

Kehinde, F. ., & Aziz, H. A. (2015). Journal of Environmental Chemical Engineering Classical optimization of process variables in the treatment of real textile wastewater using clinoptilolite. *Biochemical Pharmacology*, 6–11.

Kehinde, F. O., & Aziz, H. A. (2015). Classical optimization of process variables in the treatment of real textile wastewater using clinoptilolite. *Journal of Environmental Chemical Engineering*, 6–11.

Kehinde, O. F., & Aziz, H. A. (2016). Classical optimization of process variables in the treatment of real textile wastewater using clinoptilolite. *Journal of Environmental Chemical Engineering*, *4*(1), 1242–1247.

Kenneth, A., Casimir, G., Agbaji, B. E., & Steven, A. (2015). Structural and microstructural properties of Neem husk and seed carbon activated with zinc chloride and phosphoric acid. *Journal of Chemical and Pharmaceutical Research*, *7*(3), 2470–2479.

Khah, A. M., & Ansari, R. (2009). Activated charcoal : Preparation , characterization and applications : A review article. *International Journal of ChemTech Research*, *1*(4), 859–864.

Khalil, H. P. S. A., Jawaid, M., Hassan, A., Paridah, M. T., & Zaidon, A. (2012). Oil palm biomass fibres and recent advancement in oil palm biomass fibres based hybrid biocomposites. *Composites and Their Applications*, 187–220.

Khosravi, A., Esmhosseini, M., & Khezri, S. (2014). Removal of ammonium ion from aqueous solutions using natural zeolite: Kinetic, equilibrium and thermodynamic studies. *Research on Chemical Intermediates*, *40*(8), 2905–2917.

Konduri, M. K. R., & Fatehi, P. (2017). Dispersion of kaolin particles with carboxymethylated xylan. *Applied Clay Science*, *137*, 183–191.

Kudaligama, K. V. V. S., Thurul, W. M., & Yapa, P. A. J. (2010). A cost effective solution for treatment of rubber factory wastewater. *Journal of Rubber Research*, *13*(1), 18–26.

Kumar, U. (2006). Agricultural products and by-products as a low cost adsorbent for heavy metal removal from water and wastewater : A review. *Scientific Research and Essay*, *1*(November), 33–37.

Kumari, M., & Tripathi, B. D. (2015). Efficiency of Phragmites australis and Typha latifolia for heavy metal removal from wastewater. *Ecotoxicology and Environmental Safety*, *112*, 80–6.

Kumlanghan, A., Kanatharana, P., Asawatreratanakul, P., Mattiasson, B., & Thavarungkul, P. (2008). Microbial BOD sensor for monitoring treatment of wastewater from a rubber latex industry. *Enzyme and Microbial Technology*, *42*(6), 483–491.

Lakdawala, M. M., & Patel, Y. S. (2015). Studies on Adsorption Capacity of Zeolite for Removal of Chemical and Bio-Chemical Oxygen Demands. *Chemistry Journal Vol. 1*, *1*(4), 139–143.

Lakherwal, D. (2014). Adsorption of heavy metals : A review. *International Journal of Environmental Research and Development*, *4*(1), 41–48.

Lasindrang, M., Suwarno, H., Tandjung, S. D., & Kamiso, H. N. (2015). Adsorption pollution leather tanning industry wastewater by chitosan coated coconut shell active charcoal. *Italian Oral Surgery*, *3*, 241–247.

Latifah, O., Ahmed, O. H., & Majid, N. M. A. (2017). Enhancing nitrogen availability from urea using clinoptilolite zeolite. *Geoderma*, *306*(April), 152–159.

Latiffi, N. A. A., Maya, R., Shanmugan, V. A., Pahazri, N. F., Hashim, A., & Tajuddin, R. M. (2016). Removal of nutrients from meat food processing industry wastewater by using microalgae Botryococcus Sp. *ARPN Journal of Engineering and Applied Sciences*, *11*(16), 9863–9867.

Lazim, Z. M., Hadibarata, T., Puteh, M. H., Yusop, Z., Wirasnita, R., & Mohd Nor, N. (2015). Utilization of durian peel as potential adsorbent for bisphenol a removal in aquoeus solution. *Jurnal Teknologi*, *74*(11), 109–115.

Lerdrattranataywee, W., & Kaosol, T. (2015). Effect of Mixing Time on Anaerobic Co-digestion of Palm Oil Mill Waste and Block Rubber Wastewater. *Energy Procedia*, *79*, 327–334.

Li, J., Jiang, B., Liu, Y., Qiu, C., Hu, J., Qian, G., … Ngo, H. H. (2017). Preparation and adsorption properties of magnetic chitosan composite adsorbent for Cu2+ removal. *Journal of Cleaner Production*, *158*, 51–58.

Liakos, T. I., & Lazaridis, N. K. (2016). Melanoidin removal from molasses effluents by adsorption. *Journal of Water Process Engineering*, *10*, 156–164.

Lim, A. P., & Aris, A. Z. (2014). Continuous fixed-bed column study and adsorption modeling : Removal of cadmium (II) and lead (II) ions in aqueous solution by dead calcareous skeletons. *Biochemical Engineering Journal*, *87*, 50–61.

Lim, C. K., Bay, H. H., Neoh, C. H., Aris, A., Abdul Majid, Z., & Ibrahim, Z. (2013). Application of zeolite-activated carbon macrocomposite for the adsorption of Acid Orange 7: Isotherm, kinetic and thermodynamic studies. *Environmental Science and Pollution Research*, *20*, 7243–7255.

Lim, C. K., Seow, T. W., Neoh, C. H., Md Nor, M. H., Ibrahim, Z., Ware, I., & Mat Sarip, S. H. (2016). Treatment of landfill leachate using ASBR combined with zeolite adsorption technology. *3 Biotech*, *6*(2), 1–6.

Liu, Q. Q., Tan, X., & Zhao, L. (2011). Experimental study on the ammonium ion-exchange material and its removal of ammonia nitrogen from water. *Advanced Materials Research*, *183–185*, 1558–1562.

Liu, X., & Zhang, L. (2015). Removal of phosphate anions using the modified chitosan beads: Adsorption kinetic, isotherm and mechanism studies. *Powder Technology*, *277*, 112–119.

Llanes-Monter, M. M., Olguín, M. T., & Solache-Ríos, M. J. (2007). Lead sorption by a Mexican, clinoptilolite-rich tuff. *Environmental Science and Pollution Research International*, *14*(6), 397–403.

Magriotis, Z. M., Leal, P. V. B., Sales, P. F. De, Papini, R. M., Viana, P. R. M., & Augusto, P. (2014). A comparative study for the removal of mining wastewater by kaolinite , activated carbon and beta zeolite. *Applied Clay Science*, *91–92*, 55–62.

Mahmoodi, M. N., Salehi, R., Arami, M., & Bahrami, H. (2011). Dye removal from colored textile wastewater using chitosan in binary systems. *Desalination*, *267*(1), 64–72.

Mamun, A. A., & Zainudin, Z. (2013). Sustainable river water quality management in Malaysia. *IIUM Engineering Journal*, *14*(1), 29–42.

Mandal, N. K. (2014). Performance of low-cost bio adsorbents for the removal of metal ions – A review. *International Journal of Science and Research (IJSR)*, *3*(1), 177–180.

Mangaleshwaran, L., Thirulogachandar, A., Rajasekar, V., Muthukumaran, C., & Rasappan, K. (2015). Batch and fixed bed column studies on nickel (II) adsorption from aqueous solution by treated polyurethane foam. *Journal of the Taiwan Institute of Chemical Engineers*, *55*, 112–118.

Markou, G. (2015). Fed-batch cultivation of Arthrospira and Chlorella in ammonia-rich wastewater: Optimization of nutrient removal and biomass production. *Bioresource Technology*, *193*, 35–41.

Marković, M., Daković, A., Rottinghaus, G. E., Petković, A., Kragović, M., Krajišnik, D., & Milić, J. (2017). Ochratoxin A and zearalenone adsorption by the natural zeolite treated with benzalkonium chloride. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, *529*(March), 7–17.

Marrakchi, F., Khanday, W. A., Asif, M., & Hameed, B. H. (2016). Cross-linked chitosan/sepiolite composite for the adsorption of methylene blue and reactive orange 16. *International Journal of Biological Macromolecules*, *93*, 1231–1239.

Marsalek, R. (2012). Zeta Potential - Applications. In *2nd International Conference on Environment and ndustrial Innovation* (Vol. 35, pp. 15–19).

Martins, T. H., Souza, T. S. O., & Foresti, E. (2017). Ammonium removal from landfill leachate by Clinoptilolite adsorption followed by bioregeneration. *Journal of Environmental Chemical Engineering*, *5*(1), 63–68.

Mashal, A., Abu-Dahrieh, J., A. Ahmed, A., Oyedele, L., Haimour, N., Al-Haj-Ali, A., & Rooney, D. (2014). Fixed-bed study of ammonia removal from aqueous solutions using natural zeolite. *World Journal of Science, Technology and Sustainable Development*, *11*(2), 144–158.

Massoudinejad, M., Rabori, M. M., & Dehghani, M. H. (2015). Treatment of natural rubber industry wastewater through a combination of physicochemical and ozonation processes. *Journal of Advances in Environmental Health Research*, *Vol. 3*(4), 242–249.

Meena, A. K., Rajagopal, C., & Mishra, G. K. (2010). Removal of heavy metal ions from aqueous solutions using chemically (Na2S) treated granular activated carbon as an adsorbent. *Journal of Scientific & Industrial Research*, *69*(June), 449–453.

Meroufel, B., Benali, O., Benyahia, M., Benmoussa, Y., & Zenasni, M. A. (2013). Adsorptive removal of anionic dye from aqueous solutions by Algerian kaolin : Characteristics , isotherm , kinetic and thermodynamic studies. *J. Mater. Environ. Sci.*, *4*(3), 482–491.

Mirbagheri, S. A., Biglarijoo, N., & Ahmadi, S. (2013). Efficiency of Two Types of Activated Carbon Columns to Treat Industrial Wastewater : A Case Study. *International Journal of Geology*, *7*(3), 88–93.

Miretzky, P., & Cirelli, a F. (2010). Cr(VI) and Cr(III) removal from aqueous solution by raw and modified lignocellulosic materials: a review. *Journal of Hazardous Materials*, *180*(1–3), 1–19.

Mohammadi, M., Man, H. C., Hassan, M. A., & Yee, P. L. (2010). Treatment of wastewater from rubber industry in Malaysia. *Journal of Biotechnology*, *9*(38), 6233–6243.

Moideen, S. N. F., Din, M. F. M., Rezania, S., Ponraj, M., Rahman, A. A., Pei, L. W., Komori, D. (2017). Dual phase role of composite adsorbents made from cockleshell and natural zeolite in treating river water. *Journal of King Saud University - Science*, 6–11.

Moideen, S. N. F., Md Din, M. F., Ponraj, M., Mohd Yusof, M. B., Ismail, Z., Songip, A. R., & Chelliapan, S. (2016). Wasted cockle shell (*Anadara granosa*) as a natural adsorbent for treating polluted river water in the fabricated column model (FCM). *Desalination and Water Treatment*, *57*(35), 16395–16403.

Mojiri, A. (2011). Review on Membrane Bioreactor , Ion Exchange and adsorption Methods for Landfill Leachate Treatment. *Australian Journal of Basic and Applied Sciences*, *5*(12), 1365–1370.

Mokhtar, N. M., Lau, W. J., Ismail, A. F., & Veerasamy, D. (2015). Membrane distillation technology for treatment of wastewater from rubber industry in Malaysia. *Procedia CIRP*, *26*(November), 792–796.

Mouni, L., Belkhiri, L., Bollinger, J. C., Bouzaza, A., Assadi, A., Tirri, A., … Remini, H. (2018). Removal of Methylene Blue from aqueous solutions by adsorption on Kaolin: Kinetic and equilibrium studies. *Applied Clay Science*, *153*(December 2017), 38–45.

Mukherjee, S., Pariatamby, A., Sahu, J. N., & Sen Gupta, B. (2013). Clarification of rubber mill wastewater by a plant based biopolymer - comparison with common inorganic coagulants. *Journal of Chemical Technology & Biotechnology*, *88*(10), 1864–1873.

Musso, T. B., Parolo, M. E., Pettinari, G., & Francisca, F. M. (2014). Cu(II) and Zn(II) adsorption capacity of three different clay liner materials. *Journal of Environmental Management*, *146*, 50–58.

Nair, V., Panigrahy, A., & Vinu, R. (2014). Development of novel chitosan–lignin composites for adsorption of dyes and metal ions from wastewater. *Chemical Engineering Journal*, *254*, 491–502.

Naiya, T. K., Singha, B., & Das, S. K. (2011). FTIR study for the Cr (VI) removal from aqueous solution using rice waste. In *International Proceedings of Chemical, Biological and Environmental Engineering (IPCBEE)* (Vol. 10, pp. 114–119).

Nandi, B. K., Goswami, A., & Purkait, M. K. (2009a). Adsorption characteristics of brilliant green dye on kaolin. *Journal of Hazardous Materials*, *161*, 387–395.

Nandi, B. K., Goswami, A., & Purkait, M. K. (2009b). Removal of cationic dyes from aqueous solutions by kaolin : Kinetic and equilibrium studies. *Applied Clay Science*, *42*(3–4), 583–590.

Nasir, N. H. M., Zaini, M. A. ., Setapar, S. H. M. ., & Hassan, H. (2015). Removal of methylene blue and copper (II) by oil palm empty fruit. *Jurnal Teknologi*, *7*(Ii), 107–110.

Nawawi, M. G. H., Othman, N., Sadikin, A. N., & Ismail, N. C. (2008). Lignocellulosic fiber media filters as a potential technology for primary industrial wastewater treatment. *Jurnal Teknologi*, *49*, 149–157.

Nazri, N. A. M., Lau, W. J., Ismail, A. F., Matsuura, T., Veerasamy, D., & Hilal, N. (2015). Performance of PAN-based membranes with graft copolymers bearing hydrophilic PVA and PAN segments in direct ultrafiltration of natural rubber effluent. *Desalination*, *358*, 49–60.

Nethaji, S., & Sivasamy, a. (2011). Adsorptive removal of an acid dye by lignocellulosic waste biomass activated carbon: equilibrium and kinetic studies. *Chemosphere*, *82*(10), 1367–72.

Ngah, W. S. W., Teong, L. C., Toh, R. H., & Hanafiah, M. A. K. M. (2012). Utilization of chitosan – zeolite composite in the removal of Cu (II) from aqueous solution : Adsorption , desorption and fixed bed column studies. *Chemical Engineering Journal*, *209*, 46–53.

Ngah, W. S. W., Teong, L. C., Toh, R. H., & Hanafiah, M. A. K. M. (2013). Comparative study on adsorption and desorption of Cu(II) ions by three types of chitosan–zeolite composites. *Chemical Engineering Journal Journal*, 231–238.

Ngah, W. W. S., & Hanafiah, M. A. K. M. (2008). Removal of heavy metal ions from wastewater by chemically modified plant wastes as adsorbents: a review. *Bioresource Technology*, *99*(10), 3935–48.

Nguyen, N. H., & Luong, T. T. (2012). Situation of wastewater treatment of natural rubber latex processing in the Southeastern region , Vietnam. *Journal of Vietnamese Environment*, *2*(2), 58–64.

Nguyen, N. T. (2015). *Adsorption Of phosphorus from wastewater onto biochar : batch and fixed-bed column studies*. Helsinki Metropolia University of Applied Sciences.

Nguyen, T. A. H., Ngo, H. H., Guo, W. S., Pham, T. Q., Li, F. M., Nguyen, T. V, & Bui, X. T. (2015). Adsorption of phosphate from aqueous solutions and sewage using zirconium loaded okara (ZLO): Fixed-bed column study. *Science of the Total Environment*, *523*, 40–49.

Nitayaphat, W. (2014). Utilization of chitosan/bamboo charcoal composite as reactive dye adsorbent. *Chiang Mai Journal of Science*, *41*(1), 174–183.

Nitayaphat, W., & Jintakosol, T. (2015). Removal of silver (I) from aqueous solutions by chitosan / bamboo charcoal composite beads. *Journal of Cleaner Production*, *87*, 850–855.

Nunes, C. A., & Guerreiro, M. C. (2011). Estimation of surface area and pore volume of activated carbons by methylene blue and iodine numbers. *Quimica Nova*, *34*(3), 472–476.

Nwabanne, J. T., & Igbokwe, P. K. (2012a). Adsorption performance of packed bed column for the removal of Lead (ii) using oil palm fibre. *International Journal of Applied Science and Technology*, *2*(5), 106–115.

Nwabanne, J. T., & Igbokwe, P. K. (2012b). Comparative study of lead (II) removal from aqueous solution using different adsorbents. *IInternational Journal of Engineering Research and Applications (IJERA)*, *2*(4), 1830–1838.

Omorusi, & Irogue, V. (2013). Evaluation of wastewater (effluent) from rubber latex concentrate for microbiological and phyciso- chemical properties. *Journal of Chemical Information and Modeling*, *53*(5), 1689–1699.

Owamah, H. I., Enaboifo, M. A., & Izinyon, O. C. (2014). Treatment of wastewater from raw rubber processing industry using water lettuce macrophyte pond and the reuse of its effluent as biofertilizer. *Agricultural Water Management*, *146*, 262–269.

Ozdemir, O., Turan, M., Zahid, A., Faki, A., & Baki, A. (2009). Feasibility analysis of color removal from textile dyeing wastewater in a fixed-bed column system by surfactant-modified zeolite (SMZ). *Journal of Hazardous Materials*, *166*, 647–654.

Pan, M., Lin, X., Xie, J., & Huang, X. (2017). Kinetic, equilibrium and thermodynamic studies for phosphate adsorption on aluminum hydroxide modified palygorskite nano-composites. *RSC Adv.*, *7*(8), 4492–4500.

Panda, A. K., Mishra, B. G., Mishra, D. K., & Singh, R. K. (2010). Effect of sulphuric acid treatment on the physico-chemical characteristics of kaolin clay. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, *363*(1–3), 98–104.

Patel, H., & Vashi, R. T. (2015). Characterization and column adsorptive treatment for cod and color removal using activated neem leaf powder from textile wastewater. *Journal of Urban and Environmental Engineering*, *9*(1), 45–53.

Pillai, H. P. J. S., & Girish, K. (2014). Rubber processing industry effluent treatment using a bacterial consortium. *International Journal of Current Microbiology and Applied Sciences*, *3*(10), 775–782.

Pirbazari, A. E., Saberikhah, E., Badrouh, M., & Emami, M. S. (2014). Alkali treated Foumanat tea waste as an efficient adsorbent for methylene blue adsorption from aqueous solution. *Water Resources and Industry*, *6*, 64–80.

Plaza-Recobert, M., Trautwein, G., Perez-Cadenas, M., & Alcaniz-Monge, J. (2017). Preparation of binderless activated carbon monoliths from cocoa bean husk. *Microporous and Mesoporous Materials*, *243*, 28–38.

Rahman, A., Kishimoto, N., & Urabe, T. (2015). Adsorption characteristics of clay adsorbents - sepiolite, kaolin and synthetic talc - for removal of Reactive Yellow 138:1. *Water and Environment Journal*, *29*(3), 375–382.

Rahman, N., & Khan, M. F. (2016). Journal of Water Process Engineering Nitrate removal using poly- o -toluidine zirconium (IV) ethylenediamine as adsorbent : Batch and fixed-bed column adsorption modelling. *Journal of Water Process Engineering*, *9*, 254–266.

Rahmani, Z., Rahmani, A., & Poureshgh, Y. (2014). Evaluation of the removal of ammonium by kKaolin, synthesized zeolite produced from kaolin and magnetic zeolit from aqueous solutions. *Sceinces Medical*, (October 2016), 312–328.

Ramavandi, B., Farjadfard, S., & Ardjmand, M. (2014). Journal of Environmental Chemical Engineering Mitigation of orange II dye from simulated and actual wastewater using bimetallic chitosan particles : Continuous fl ow fi xed-bed reactor. *Biochemical Pharmacology*, *2*(3), 1776–1784.

Ramya, P. M., Jayasravanthi, M., Dulla, B. J., & Venkata, N. R. (2015). Chemical oxygen demand reduction from coffee processing waste water-A comparative study on usage of biosorbents prepared from agricultural wastes. *Global Nest Journal*, *17*(2), 291–300.

Rangabhashiyam, S., Anu, N., & Selvaraju, N. (2013). Journal of Environmental Chemical Engineering Sequestration of dye from textile industry wastewater using agricultural waste products as adsorbents. *Biochemical Pharmacology*, *1*(4), 629–641.

Rashed, M. N. (2013). Adsorption technique for the removal of organic pollutants from water and wastewater. *Organic Pollutants - Monitoring, Risk and Treatment*, 167–194.

Razi, M. A. M., Hishammudin, M. N. A., & Hamdan, R. (2017). Factor affecting textile dye removal using adsorbent from activated carbon : A review. In *MATEC Web of Conferences 103* (Vol. 6015, pp. 1–17).

Rebitanim, N. Z., Ghani, W. A. W. A. K., Mahmoud, D. K., Rebitanim, N. A., & Mohd Salleh, M. A. (2012). Adsorption capacity of raw empty fruit bunch biomass onto methylene blue dye in aqueous solution. *Journal of Purity, Utility Reaction and Environment*, *1*, 45–60.

Renge, V. C., Khedkar, S. V, & Pande, S. V. (2012). Removal of heavy metals from wastewater using low cost adsorbents: A review. *Scientific Reviews & Chemical Communication*, *2*(4), 580–584.

Riahi, K., Chaabane, S., & Thayer, B. Ben. (2017). A kinetic modeling study of phosphate adsorption onto Phoenix dactylifera L. date palm fibers in batch mode. *Journal of Saudi Chemical Society*, *21*(143), 152.

Ricky, L. N. S., Shahril, Y., Nurmin, B., & Zahrim, A. (2016). Ammonia-nitrogen removal from urban drainage using modified fresh empty fruit bunches: A case study in Kota Kinabalu, Sabah. *IOP Conference Series: Earth and Environmental Science*, *36*, 12055.

Rida, K., Bouraoui, S., & Hadnine, S. (2013). Adsorption of methylene blue from aqueous solution by kaolin and zeolite. *Applied Clay Science*, *83–84*, 99–105.

Rosman, N. H., Nor Anuar, A., Chelliapan, S., Md Din, M. F., & Ujang, Z. (2014a). Characteristics and performance of aerobic granular sludge treating rubber wastewater at different hydraulic retention time. *Bioresource Technology*, *161*, 155–161.

Rosman, N. H., Nor Anuar, A., Chelliapan, S., Md Din, M. F., & Ujang, Z. (2014b). Characteristics and performance of aerobic granular sludge treating rubber wastewater at different hydraulic retention time. *Bioresource Technology*, *161*(November), 155–161.

Rosman, N. H., Nor Anuar, A., Othman, I., Harun, H., Sulong Abdul Razak, M. Z., Elias, S. H., … Ujang, Z. (2013). Cultivation of aerobic granular sludge for rubber wastewater treatment. *Bioresource Technology*, *129*(November 2015), 620–3.

Rugayah, A. F., Astimar, A. A., & Norzita, N. (2014). Preparation and characterisation of activated carbon from palm kernel shell by physical activation with steam. *Journal of Oil Palm Research*, *26*(3), 251–264.

Sahin, O., Kaya, M., & Saka, C. (2015). Applied Clay Science Plasma-surface modification on bentonite clay to improve the performance of adsorption of methylene blue. *Applied Clay Science*, *116–117*, 46–53.

Saif, M., Rehman, U., Munir, M., Ashfaq, M., Rashid, N., Faizan, M., … Han, J. (2013). Adsorption of Brilliant Green dye from aqueous solution onto red clay. *Chemical Engineering Journal*, *228*, 54–62.

Sajab, M. S., Chia, C. H., Zakaria, S., & Khiew, P. S. (2013). Cationic and anionic modifications of oil palm empty fruit bunch fibers for the removal of dyes from aqueous solutions. *Bioresource Technology*, *128*, 571–577.

Sajab, M. S., Chia, C. H., Zakaria, S., & Sillanpaa, M. (2014). Removal of organic pollutants and decolorization of bleaching effluent from pulp and paper mill by adsorption using chemically treated oil palm empty fruit bunch fibers. *BioResources*, *9*(3), 4517–4527.

Sajab, M. S., Chia, C. H., Zakaria, S., & Sillanpää, M. (2015). Fixed-bed column studies for the removal of cationic and anionic dyes by chemically modified oil palm empty fruit bunch fibers: single- and multi-solute systems. *Desalination and Water Treatment*, (August 2015), 1–8.

Saka, C., Şahin, Ö., & Küçük, M. M. (2012). Applications on agricultural and forest waste adsorbents for the removal of lead (II) from contaminated waters. *International Journal of Environmental Science and Technology*, *9*(2), 379–394.

Salam, O. E. A., Neama, R. A., & ElShafaei, M. M. (2011). A study of the removal characteristics of heavy metals from wastewater by low-cost adsorbents. *Journal of Advanced Research*, *2*(4), 297–303.

Salman, M., Athar, M., Shafique, U., Rehman, R., Ameer, S., Ali, S. Z., & Azeem, M. (2012). Removal of formaldehyde from aqueous solution by adsorption on kaolin and bentonite: A comparative study. *Turkish Journal of Engineering and Environmental Sciences*, *36*(3), 263–270.

Samadi, N., Hasanzadeh, R., & Rasad, M. (2014). Adsorption isotherms, kinetic, and desorption studies on removal of toxic metal ions from aqueous solutions by polymeric adsorbent. *Journal of Applied Polymer Science*, *41642*.

Saravanan, D., Gomathi, T., & Sudha, P. N. (2013). Sorption studies on heavy metal removal using chitin / bentonite biocomposite. *International Journal of Biological Macromolecules*, *53*, 67–71.

Seey, T. L., & Kassim, M. J. N. (2012). Acidic and basic dyes removal by adsorption on chemically treated mangrove barks. *International Journal of Applied Science and Technology*, *2*(3), 270–276.

Sen, T. K., & Khoo, C. (2013). Adsorption characteristics of zinc (Zn2+) from aqueous solution by natural bentonite and kaolin clay minerals: A comparative study. *Computational Water, Energy, and Environmental Engineering*, *2*(3), 1–6.

Seniūnaitė, J., Vaiškūnaitė, R., & Bolutienė, V. (2014). Coffee grounds as an adsorbent for copper and lead removal form aqueous solutions. In *The 9th International Conference "Environmental Engineering"* (pp. 1–6).

Shao, H., Zhang, Z. F., & Cao, N. (2012). Study on the industrial wastewater treatment by modified bentonite. *Applied Mechanics and Materials*, *182–183*, 323–327.

Sharma, P. K., Ayub, S., & Tripathi, C. N. (2013). Agro and horticultural wastes as low cost adsorbents for removal of heavy metals from wastewater : A review. *International Refereed Journal of Engineering and Science (IRJES)*, *2*(8), 18–27.

Shruthi, S., Raghavendra, M. p., Smitha, S. H. S., & Girish, K. (2012). Bioremediation of rubber processing industry effluent by Pseudomonas sp. *International Journal of Research in Environmental Science and Technology*, *2*(APRIL), 27–30.

Simate, G. S., & Ndlovu, S. (2015). The removal of heavy metals in a packed bed column using immobilized cassava peel waste biomass. *Journal of Industrial and Engineering Chemistry*, *21*, 635–643.

Singh, U., & Kaushal, R. K. (2013). Treatment of wastewater with low cost adsorbent-Review. *International Journal of Technical & Non-Technical Research*, *4*(3), 33–42.

Širc, J., Hobzová, R., Kostina, N., Munzarová, M., Juklíčková, M., Lhotka, M., … Michálek, J. (2012). Morphological characterization of nanofibers: Methods and application in practice. *Journal of Nanomaterials*, *2012*.

Smith, M. C., Crist, R. M., Clogston, J. D., & McNeil, S. E. (2017). Zeta potential: a case study of cationic, anionic, and neutral liposomes. *Analytical and Bioanalytical Chemistry*.

Smitha, H. S. S., Raghavendra, M. P., Shruthi, S., & Girish, K. (2012). Bioremediation of rubber processing industry effluent by Arthrobacter sp. *International Journal of Research in Environmental Science and Technology*, *2*(2), 31–34.

Sugashini, S., Begum, K. M. M. S., & Ramalingam, A. (2015). Removal of Cr(VI) ions using Fe-loaded chitosan carbonized rice husk composite beads (Fe-CCRCB): Experiment and quantum chemical calculations. *Journal of Molecular Liquids*, *208*, 380–387.

Suhas, Carrott, P. J. M., Ribeiro Carrott, M. M. L., Singh, R., Singh, L. P., & Chaudhary, M. (2017). An innovative approach to develop microporous activated carbons in oxidising atmosphere. *Journal of Cleaner Production*, *156*, 549–555.

Suradi, S. S., Yunus, R. M., Beg, M. D. H., & Yusof, Z. A. M. (2009). National Conference on Postgraduate Research (NCON-PGR) 2009 1st October 2009, UMP Conference Hall, Malaysia © Centre for Graduate Studies, Universiti Malaysia Pahang Editors: M.M. Noor; M.M. Rahman and K. Kadirgama, (October), 67–78.

Tahir, N., & Majid, Z. A. (2013). Equilibrium and kinetic studies of acid dye adsorption on palm oil empty fruit bunch. *Malaysian Journal of Fundamental and Applied Sciences*, *Vol. 9*, 143–149.

Tanikawa, D., Syutsubo, K., Watari, T., Miyaoka, Y., Hatamoto, M., Iijima, S., … Yamaguchi, T. (2016). Greenhouse gas emissions from open-type anaerobic wastewater treatment system in natural rubber processing factory. *Journal of Cleaner Production*, 1–15.

Tehrani-Bagha, A. R., Nikkar, H., Mahmoodi, N. M., Markazi, M., & Menger, F. M. (2011). The sorption of cationic dyes onto kaolin: Kinetic, isotherm and thermodynamic studies. *Desalination*, *266*(1–3), 274–280.

Temel, F. A., & Kuleyin, A. (2016). Ammonium removal from landfill leachate using natural zeolite: kinetic, equilibrium, and thermodynamic studies. *Desalination and Water Treatment*, *3994*(January), 1–20.

Tran, H. V., Tran, L. D., & Nguyen, T. N. (2010). Preparation of chitosan/magnetite composite beads and their application for removal of Pb(II) and Ni(II) from aqueous solution. *Materials Science and Engineering C*, *30*(2), 304–310.

Trgo, M., Perić, J., & Medvidović, N. V. (2006). A comparative study of ion exchange kinetics in zinc/lead-modified zeolite-clinoptilolite systems. *Journal of Hazardous Materials*, *136*(3), 938–945.

Vakili, M., Rafatullah, M., Ibrahim, M. H., Abdullah, A. Z., Salamatinia, B., & Gholami, Z. (2014). Oil palm biomass as an adsorbent for heavy metals. *Reviews of Environmental Contamination and Toxicology*, *232*, 1–44.

Vakili, M., Rafatullah, M., Ibrahim, M. H., Abdullah, A. Z., Salamatinia, B., & Gholami, Z. (2016). Chitosan hydrogel beads impregnated with hexadecylamine for improved reactive blue 4 adsorption. *Carbohydrate Polymers*, *137*, 139–146.

Vakili, M., Rafatullah, M., Salamatinia, B., Zuhairi, A., Hakimi, M., Bing, K., … Amouzgar, P. (2014). Application of chitosan and its derivatives as adsorbents for dye removal from water and wastewater : A review. *Carbohydrate Polymers*, *113*, 115–130.

Varma, G. V., Singh, R. K., & Sahu, V. (2013). A comparative study on the removal of heavy metals by adsorption using fly ash and sludge : A review. *International Journal of Application or Innovation in Engineering & Management*, *2*(7), 45–56.

Vijayaraghavan, K., Ahmad, D., & Ahmad Yazid, A. Y. (2008). Electrolytic treatment of latex wastewater. *Desalination*, *219*(1–3), 214–221.

Vimonses, V., Lei, S., Jin, B., Chow, C. W. K., & Saint, C. (2009). Adsorption of congo red by three Australian kaolins. *Applied Clay Science*, *43*(3–4), 465–472.

Višekruna, A., Štrkalj, A., & Pajc, L. M. (2011). The use of low cost adsorbent for purification wastewater. *The Holistic Approach to Environment*, *1*, 29–37.

Waajen, G. W. A. M., Van Bruggen, N. C. B., Pires, L. M. D., Lengkeek, W., & Lürling, M. (2016). Biomanipulation with quagga mussels (Dreissena rostriformis bugensis) to control harmful algal blooms in eutrophic urban ponds. *Ecological Engineering*, *90*, 141–150.

Waghmare, S., Arfin, T., Rayalu, S., Lataye, D., Dubey, S., & Tiwari, S. (2015). Adsorption behaviour of modified zeolite as novel adsorbents for fluoride removal from drinking water : surface phenomena , kinetics and thermodynamics studies. *International Journal of Science, Engineering and Technology Research*, *4*(12), 4114–4124.

Wahab, M. A., Boubakri, H., Jellali, S., & Jedidi, N. (2012). Characterization of ammonium retention processes onto Cactus leaves fibers using FTIR, EDX and SEM analysis. *Journal of Hazardous Materials*, *241–242*, 101–109.

Wahab, M. A., Jellali, S., & Jedidi, N. (2010). Ammonium biosorption onto sawdust: FTIR analysis, kinetics and adsorption isotherms modeling. *Bioresource Technology*, *101*(14), 5070–5075.

Wahi, R., Ngaini, Z., & Jok, V. U. (2009). Removal of mercury , lead and copper from aqueous solution by activated carbon of palm oil empty fruit bunch. *World Applied Sciences Journal*, *5*, 84–91.

Wan Ngah, W. S., Teong, L. C., & Hanafiah, M. a. K. M. (2011). Adsorption of dyes and heavy metal ions by chitosan composites: A review. *Carbohydrate Polymers*, *83*(4), 1446–1456.

Wang, H., Dong, Y. nan, Zhu, M., Li, X., Keller, A. A., Wang, T., & Li, F. (2015). Heteroaggregation of engineered nanoparticles and kaolin clays in aqueous environments. *Water Research*, *80*, 130–138.

Wang, J., Liu, Y., Jin, Y., Tian, X., & Xu, X. (2013). Application of bioaugmentation for natural rubber wastewater treatment in A 2 O process. *Journal of Chemical and Pharmaceutical Research*, *5*(12), 319–322.

Wang, J., Tang, X., Liu, Y., Jin, Y., Liu, Y., Cheng, J., & Xu, X. (2013). Start-up of a bioaugmentation anoxic-oxic (A/O) biofilm process treating natural rubber wastewater. *BioTechnology An Indian Journal*, *7*(10), 402–406.

Wang, S., & Peng, Y. (2010). Natural zeolites as effective adsorbents in water and wastewater treatment. *Chemical Engineering Journal*, *156*, 11–24.

Wang, W., Li, M., & Zeng, Q. (2015). Adsorption of chromium (VI) by strong alkaline anion exchange fiber in a fixed-bed column : Experiments and models fitting and evaluating. *Separation and Purification Technology*, *149*(5), 16–23.

Wardhana, Y. W., Hasanah, A. N. U. R., & Primandini, P. (2014). Deformation and adsorption capacity of kaolin that is influenced by temperature variation on calcination. *International Journal of Pharmacy and Pharmaceutical Sciences*, *6*, 6–7.

Watari, T., Mai, T. C., Tanikawa, D., Hirakata, Y., Hatamoto, M., Syutsubo, K., … Yamaguchi, T. (2017a). Performance evaluation of the pilot scale upflow anaerobic sludge blanket – D ownflow hanging sponge system for natural rubber processing wastewater treatment in South Vietnam. *Bioresource Technology*.

Watari, T., Mai, T. C., Tanikawa, D., Hirakata, Y., Hatamoto, M., Syutsubo, K., … Yamaguchi, T. (2017b). Performance evaluation of the pilot scale upflow anaerobic sludge blanket – Downflow hanging sponge system for natural rubber processing wastewater treatment in South Vietnam. *Bioresource Technology*, *237*, 204–212.

Wijesinghe, D. T. N., Dassanayake, K. B., Sommer, S. G., Jayasinghe, G. Y., J. Scales, P., & Chen, D. (2016). Ammonium removal from high-strength aqueous solutions by Australian zeolite. *Journal of Environmental Science and Health - Part A Toxic/Hazardous Substances and Environmental Engineering*, *51*(8), 614–625.

Wirasnita, R., Hadibarata, T., Mohd Yusoff, A. R., & Mat Lazim, Z. (2015). Preparation and characterization of activated carbon from oil palm empty fruit bunch wastes using zinc chloride. *Jurnal Teknologi*, *74*(11).

Worch, E. (2012). *Adsorption Technology in Water Treatment: Fundamentals, Processes, and Modeling*. Germany: Dresden University of Technology.

Xin, G., Lopes, M. P., Crespo, J. G., & Rusten, B. (2013a). A continuous nanofiltration+evaporation process for high strength rubber wastewater treatment and water reuse. *Separation and Purification Technology*, *119*(SEPT), 19–27.

Xin, G., Lopes, M. P., Crespo, J. G., & Rusten, B. (2013b). A continuous nanofiltration+evaporation process for high strength rubber wastewater treatment and water reuse. *Separation and Purification Technology*, *119*, 19–27.

Xu, Z., Cai, J.-G., & Pan, B.-C. (2013). Mathematically modeling fixed-bed adsorption in aqueous systems. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, *14*(3), 155–176.

Yaneva, Z. L., Koumanova, B. K., & Allen, S. J. (2013). Applicability comparison of different kinetic/diffusion models for 4-nitrophenol sorption on Rhizopus oryzae dead biomass. *Bulgarian Chemical Communications*, *45*(2), 161–168.

Yavuz, Ö., & Saka, C. (2013). Surface modification with cold plasma application on kaolin and its effects on the adsorption of methylene blue. *Applied Clay Science*, *85*(1), 96–102.

Ye, S. C., Latif, P. A., Ibrahim, S., Rosli, N., & Aziz, S. (2010). Effect of ultrasonic irradiation on COD and TSS in raw rubber mill effluent. *EnvironmentAsia*, 32–35.

Yildiz, S. (2017). Kinetic and Isotherm Analysis of Cu(II) Adsorption onto Almond Shell (Prunus Dulcis). *Ecological Chemistry and Engineering S*, *24*(1), 87–106.

Zahrim, A., Lija, Y., Ricky, L. N. S., & Azreen, I. (2016). Fruit waste adsorbent for ammonia nitrogen removal from synthetic solution: Isotherms and kinetics. *IOP Conference Series: Earth and Environmental Science*, *36*(June), 12028.

Zahrim, A. Y., Ricky, L. N. S., Hilal, N., & Tamrin, K. F. (2017). Ammonia-Nitrogen Recovery from Synthetic Solution using Agricultural Waste Fibers. *Indian Journal of Science and Technology*, *10*(6), 1–5.

Zani, R. A. M., Ahmad, N. H., & Razak, S. R. (2016). Synthesis and Characterisation of Silver nanoparticles using vernonia cinerea aqueous extract and their cytotoxicity activity against kasumi. *Jurnal Teknology*, *3*, 57–65.

Zen, N. I. M., Gani, S. S. A., Shamsudin, R., & Masoumi, H. R. F. (2015). The use of D-optimal mixture design in optimizing development of okara tablet formulation as a dietary supplement. *Scientific World Journal*, *2015*, 1–6.

Zhang, L., Hu, P., Wang, J., & Huang, R. (2016). Crosslinked quaternized chitosan/bentonite composite for the removal of Amino black 10B from aqueous solutions. *International Journal of Biological Macromolecules*, *93*, 217–225.

Zhang, L., Hu, P., Wang, J., Liu, Q., & Huang, R. (2015a). Adsorption of methyl orange (MO) by Zr (IV)-immobilized cross-linked chitosan/bentonite composite. *International Journal of Biological Macromolecules*, *81*, 818–827.

Zhang, L., Hu, P., Wang, J., Liu, Q., & Huang, R. (2015b). International Journal of Biological Macromolecules Adsorption of methyl orange (MO) by Zr (IV) - immobilized cross-linked chitosan / bentonite composite. *International Journal of Biological Macromolecules*, *81*, 818–827.

Zhao, S., Zhou, F., Li, L., Cao, M., Zuo, D., & Liu, H. (2012). Removal of anionic dyes from aqueous solutions by adsorption of chitosan-based semi-IPN hydrogel composites. *Composites Part B: Engineering*, *43*(3), 1570–1578.

Zhao, Y., Niu, Y., Hu, X., Xi, B., Peng, X., Liu, W., … Wang, L. (2016). Removal of ammonium ions from aqueous solutions using zeolite synthesized from red mud. *Desalination and Water Treatment*, *57*(10), 4720–4731.

Zhao, Y., Zhao, X., Deng, J., & He, C. (2016). Utilization of chitosan–clinoptilolite composite for the removal of radiocobalt from aqueous solution: kinetics and thermodynamics. *Journal of Radioanalytical and Nuclear Chemistry*, *308*(2), 701–709.

Zheng, L., Wang, C., Shu, Y., Yan, X., & Li, L. (2015). Utilization of diatomite / chitosan – Fe (III) composite for the removal of anionic azo dyes from wastewater : Equilibrium , kinetics and thermodynamics. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, *468*, 129–139.

Zwain, H. M., Vakili, M., & Dahlan, I. (2014). Waste material adsorbents for zinc removal from wastewater : A Comprehensive review. *International Journal of Chemical Engineering*, *2014*, 1–13.